Broiler activity and distribution as behavior-based welfare indicators

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Abstract

Two of the main aspects that broiler farmers use during daily visual checking of the performance of the flock are the activity and distribution patterns that chickens show during their farm visit. Precision Livestock Farming (PLF) technologies allow to monitor such flock behaviour indicators in a continuous and automated way in the house and this 24 hours a day and 7 days a week. The aim of this study is to show how the monitoring of activity and distribution of the flock can be used to check the welfare status of the flock.

In a commercial broiler house we used four top view cameras to generate a visualization of the floor area. The cameras recorded images continuously during the light periods of every cycle and these images were translated into activity and distribution indexes per minute. The monitoring of activity and distribution indexes through successive light periods for different cycles was linked to the welfare quality assessment scores by human experts, showing that the activity and distribution relate to broiler welfare scores.

Keywords: broilers, activity, distribution, behaviour, welfare, precision livestock farming

Introduction

Global demand for livestock products will increase with 70% by 2050. Chicken meat is one of the lowest cost sources to provide food with high-quality protein, and a low level of fat with a desirable fatty acid profile, as well as the most environmental friendly meat to produce (FAO, 2014).

In more countries, the farming methods shifted from extensive to intensive, involving the breeding of thousands of animals and a more industrialised and commercially oriented process, making farmers lose contact with their animals and having to spend more time in administrative, technical, organisational and logistic matters. To overcome this situation, Precision Livestock Farming (PLF) technology can support farmers in their daily routine of animal management, through monitoring of farm animals continuously during their life in an automated, non-invasive,

non-intrusive way, without inducing additional stress in the animals. (Tullo et al. 2005, Berckmans 2008).

Two of the main aspects broiler farmers consider in relation to the performance and status of the flock are the activity and distribution patterns that chickens show each day. Several examples exist in literature, where using camera-based technology were possible to monitor activity and distribution in broilers, both at experimental and commercial level (De Wet et al. 2003, Dawkins et al. 2012) and an early warning system to monitor deviations in the activity and/or distribution patterns was developed (Kashiha et al., 2013). There are also studies in which the relation between these deviations and the assessment of broiler chicken welfare was investigated (Weeks et al., 2000, Aydin et al. 2010, Dawkins et al. 2013).

The aim of this study is to analyse whether the results of automated monitoring of activity and distribution of the flock during the complete growth period in a commercial farm relates the welfare scores from the assessments by human experts.

Animals, Materials and Methods

Animals and housing

A commercial broiler farm located in The Netherlands contribute to this study. Five complete growing cycles were monitored. The broiler flocks in each cycle contained between 27,300 and 27,800 birds of genotype Ross 308. The animals were housed in concrete floored house (1298 m^2) with underfloor heating (first ten days), pad cooling and minimum transitional tunnel ventilation. During the rearing period, five types of feed pellets were allocated in succession. Wheat was mixed with the feed, and increased gradually (1%) during the rearing period. Drinking water was provided ad libitum by nipples with cups. Daily light schemes were divided in four blocks of six hours, with a two hour dark period in each block.

Recording system

In the farm house one eYeNamic™ system with four cameras (Fancom BV) were used in order to record image data every minute during every light period of the cycle. eYeNamic™ is a top view camera system that performs measurements of activity and distribution of the animals. It generates a visualization of the floor area and image analysis software translates the acquired images into indexes of activity and distribution. These indexes are a measure of animal movement and position. Data collection consists of collecting two raw images per minute. Every raw image is divided in squares, which are in the reality 1m by 1m at floor level for poultry (Figure 1) with a total surface area of 70 m^2. The data coming out the eYeNamic™ software is a value of activity and distribution for each square.

In this study, the activity and distribution of the flock have been analysed, both at house and camera level. The activity and distribution indexes supplied by each individual camera at the house have been used to work at individual camera level, while an average index from all the individual camera indexes of activity and distribution has been calculated in order to work at complete house level.

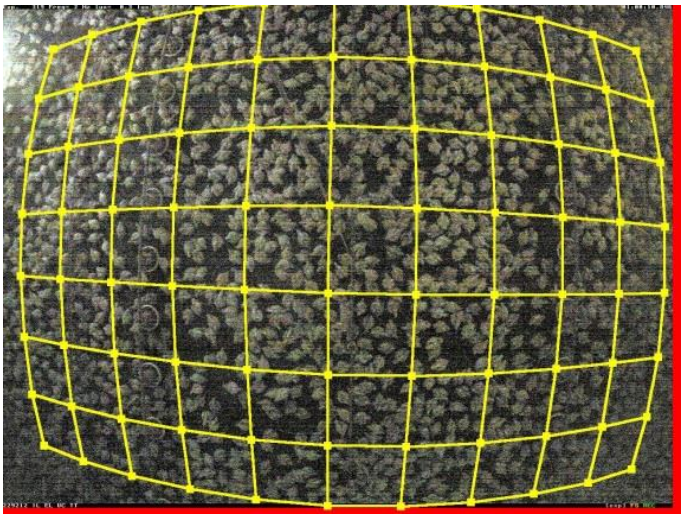

Figure 1: eYeNamic Matrix that divides the raw input image into 1m by 1m squares

Assessments of broiler chicken welfare

For every cycle three assessments of broiler chicken welfare were performed in week 3, 4 and 5. These assessments were performed according to the standardised Welfare Quality® assessment protocol for broiler chickens. In this study the welfare scores for foot pad lesions, hock burns and gait have been used. The assessor specified the different locations in the farm where he was performing these scorings in order to allow a comparison, not only between the scores and the activity and distribution at complete house level but also between the scoring results gathered in an area near to each individual camera in the house.

Data Analysis

The early warning system described by Kashiha et al. (2013) was used to detect deviations in the activity and distribution patterns showed by the flock during each growing cycle, both at complete house and individual camera level. These alerts raised by the system when a deviation from the expected activity or distribution level was found, have been grouped at different levels: no alert, yellow alert (deviation from the expected value between 15 and 25%) and red alert (deviation from the expected value higher than 25%). This outcome is presented as the percentage of time birds have been or have not been in each one of the alert situations along the cycle. The percentage of errors during the monitoring process was shown in order to have an indication of the performance of the system. Usually, these errors are due to changes in the light scheme or lack of data to perform an accurate estimation of the activity and distribution patterns.

The relation between the percentage of time birds have spent in an specific alert situation and the percentage of birds showing an specific foot pad lesion, hock burn or gait score value was investigated by means of a linear regression analysis using MATLAB® (The Mathworks, Inc.) software. The significance of the model was determined by means of the goodness of the fit (R^2) and the statistical test for the analysis of the variance (ANOVA) in terms of the p-value.

Results and Discussion

For every growth period in the farm, the activity and distribution indexes were monitored using the early warning detection system, both at house and individual camera level. In Fig.2 the percentage of time birds spent in each one of the alert situations along the different cycles according to the monitoring of activity and distribution at house level is shown. The green colour shows the percentage of time the birds spent in a no alert situation, the yellow colour the time they spent showing an activity or distribution pattern slightly (15-25%) different from the expected one and the red colour the time the activity or distribution patterns showed a clear deviation (> 25%). The black colour shows the percentage of errors during the monitoring process.

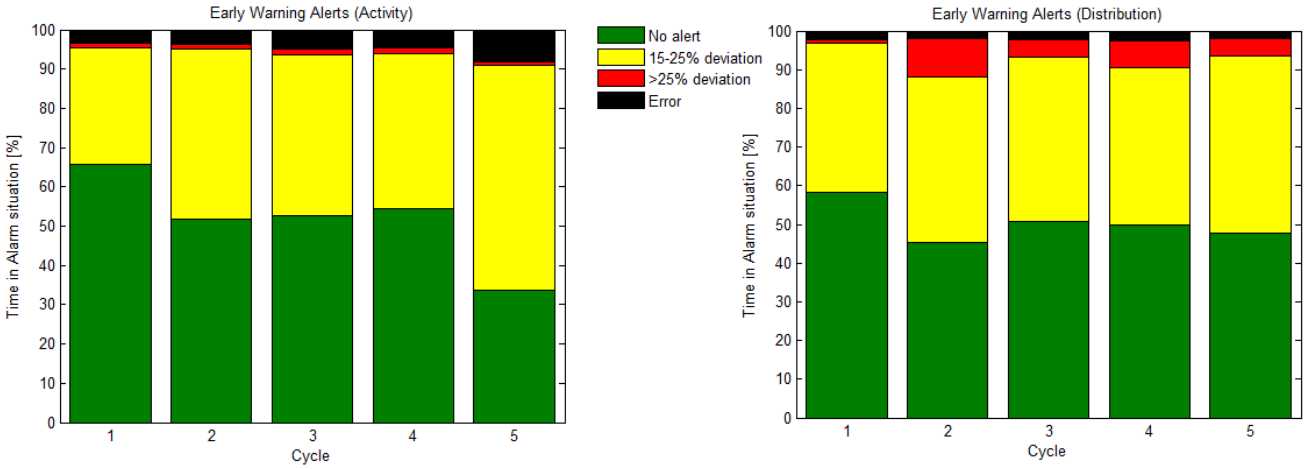

Figure 2. Percentage of time along in each cycle that the birds spent in each alert situation defined for the monitoring of activity (left) and distribution (right) indexes for the complete house.

In Fig.3 an example of the welfare scoring results for foot pad lesions, hock burn and gait is shown. These scorings were performed for every monitored growth period. The scoring from the last assessment in week 5 was the one used to be compared with the outcome of the early warning system for activity and distribution, as this outcome is the result of the analysis of the complete cycle. A score of '0' refers to no presence of foot pad lesions, no deviation of gait and no hock burns present. A score of level '4' refers to severe injuries and a severely impaired welfare.

A linear regression was used to evaluate the relation between the time percentage in an alert situation at house level and the welfare scores. No statistically relevant relation ($p > 0.05$) was found between the percentage of time in a specific alert situation, or combinations of them, regarding activity and distribution of broilers and the welfare scores. The same analysis was performed removing the data from the last cycle, due to some missing data gaps along the growth period, but similar results as in the analysis using the complete dataset were obtained.

The analysis of the output from the early warning system in terms of the percentage of time birds in a flock spend in a specific alert situation during the cycle at complete house level seem not to be related ($p > 0.05$) with foot pad lesions, hock burns and gait score registered during the assessments.

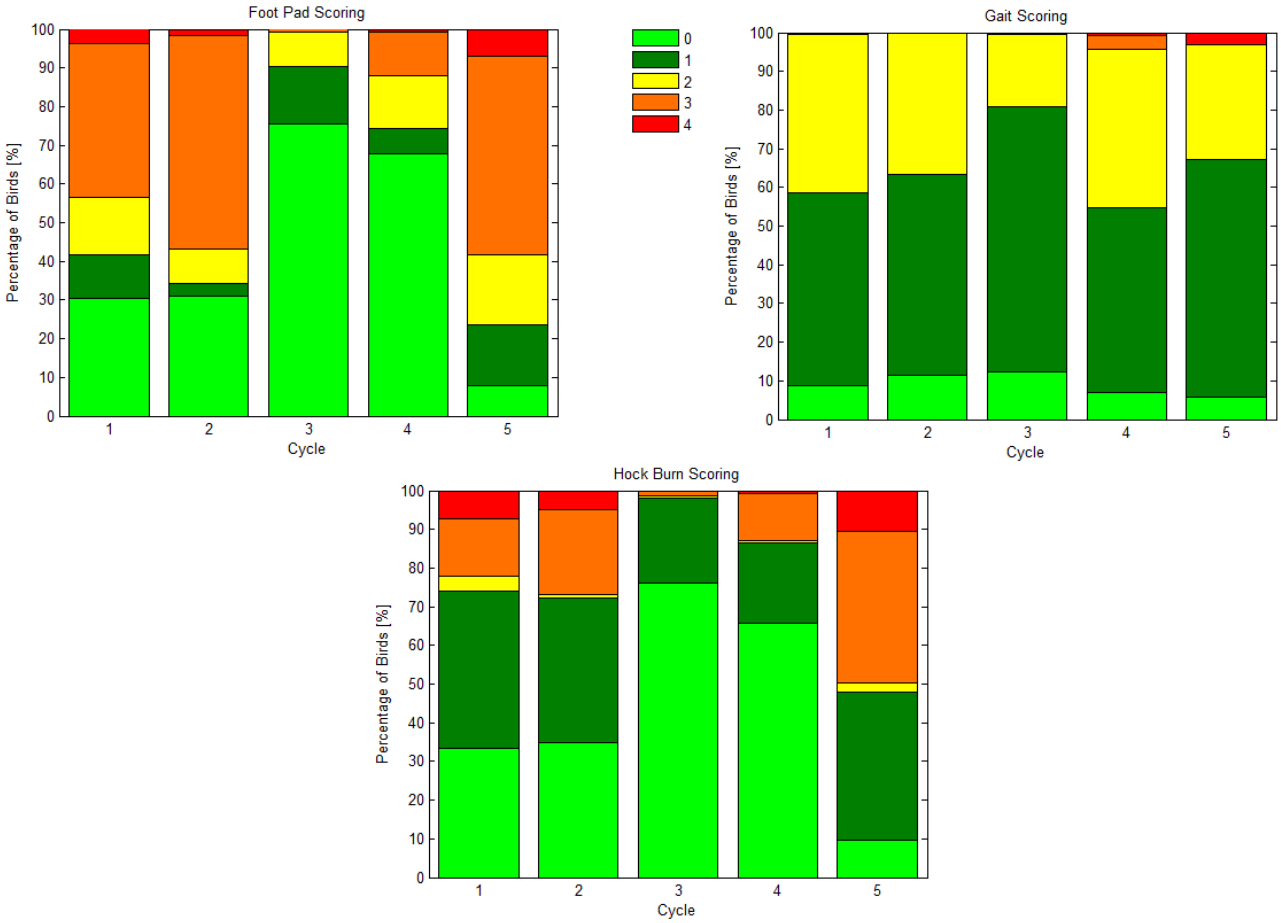

Figure 3. Foot pad lesions (upper left), hock burn (lower) and gait (upper right) scores from the final assessment in each one of the growth periods monitored.

The same procedure was applied but taking into account only the activity and distribution indexes generated by each individual camera in the house and comparing them with the welfare scores gathered on their vicinities. Fig. 4 and 5 show examples of the results obtained by monitoring the activity and distribution indexes from each individual camera along different growth periods and the welfare scores from the scoring performed in the vicinity of the camera, respectively.

A linear regression was used to evaluate the relation between the time percentage in an alert situation at camera level and the welfare scores. Statistically relevant linear relations ($p < 0.05$) were found between the percentage of time in a specific alert situation, or combinations of them, regarding activity and distribution of broilers in each specific camera and the welfare scores on its vicinity, when the data from the last cycle was taken out of the analysis. Fig. 6 shows two examples of the relation obtained through the linear regression analysis.

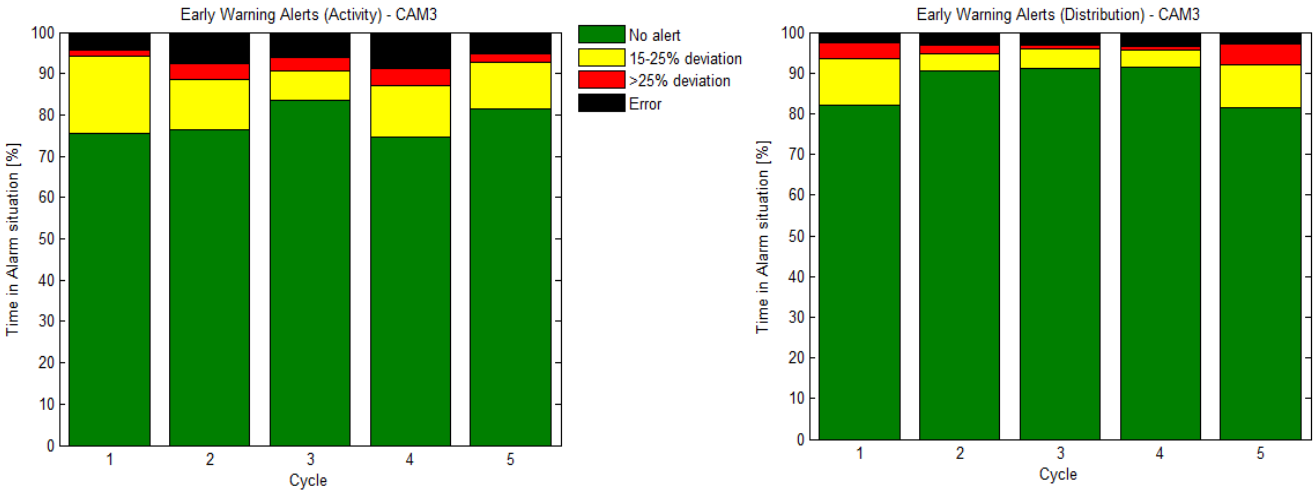

Figure 4. Percentage of time within each cycle that the birds spent in each of the alert situations, defined according to the monitoring of activity (left) and distribution (right) indexes for the camera with label 3 in the house.

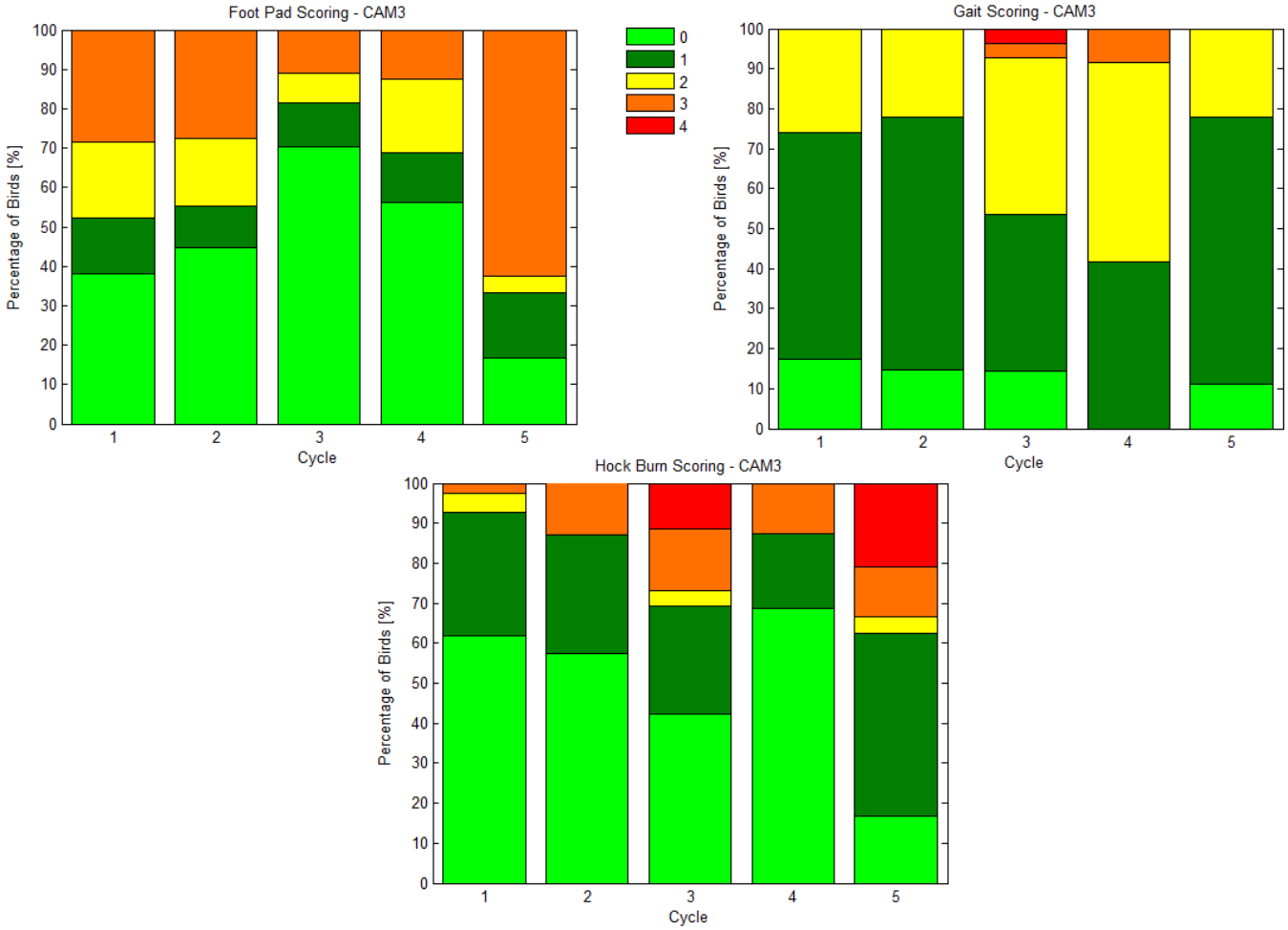

Figure 5. Foot pad lesions (upper left), hock burn (lower) and gait (upper right) scores from the final assessment in each one of the growth periods monitored in the vicinity of the camera with label 3 in the house.

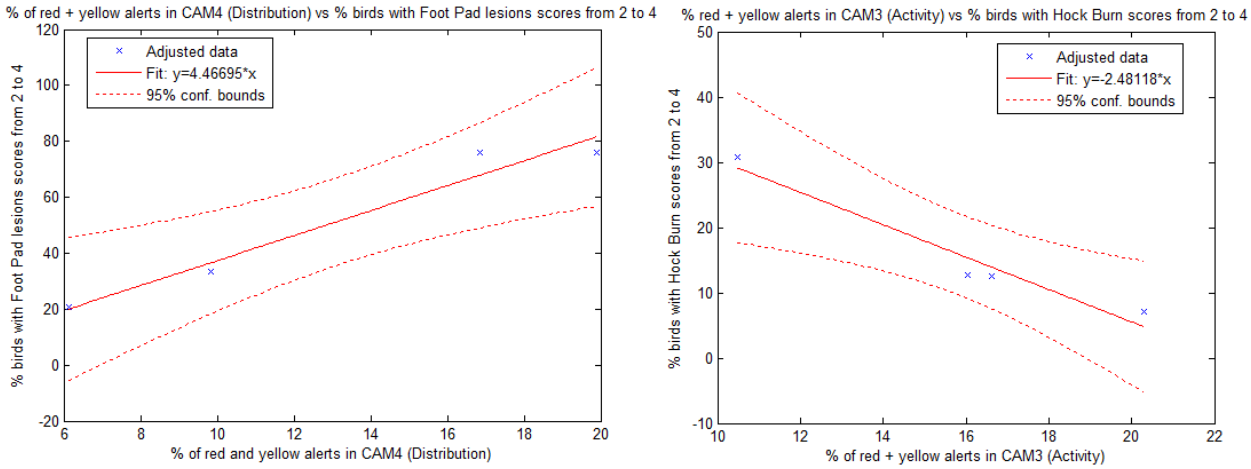

Figure 6. Statistically relevant correlations ($p < 0.05$) between the combination of the percentage of time in red and yellow alerts in distribution under camera labelled as 4 in the house and the percentage of birds with foot pad lesions scores ranging from 2 to 4, with $R^2 = 0.96$ (left), and the combination of the percentage of time in red and yellow alerts in activity under camera labelled as 3 in the house and the percentage of birds with hock burn scores ranging from 2 to 4, with $R^2 = 0.94$ (right).

These results show that when the analysis was performed at individual camera level in the house, and the deviations in the activity and distribution patterns of the birds in its vicinity are compared with the welfare scores registered in that specific area of the house, a statistically relevant relation between them was found. It seems to be a relation between the percentage of time in red and yellow alerts in distribution and the percentage of birds with foot pad lesions scores ranging from 2 to 4, and between the combination of the percentage of time in red and yellow alerts in activity and the percentage of birds with hock burn scores ranging from 2 to 4.

The relation between the deviations in distribution patterns and the foot pad lesion scores is positive. This result may indicate that birds which tend to cluster together for long periods present an increased chance for food pad lesions. The relation found between the deviations in the activity patterns and the hock burn scores is negative. This result may indicate that a higher activity of the flock would improve the hock burn scoring. This can be related with the fact that having less active broiler chickens staying still for longer periods on badly conditioned litter can worsen this kind of lesions (Haslam et al. 2007).

All the results have to be taken as preliminary, due to the small sample of this study. Information from both, more growth periods from the same farm and more farms, should be added to the study to improve the statistical relevance of the results showed in this work.

Conclusions

These results suggest that it may be possible to link deviations in activity and distribution patterns of broiler flocks in commercial farms with the welfare assessment scores by human experts. Deviations in the activity patterns seem to be related with hock burn lesion scores, while unexpected changes in the distribution patterns seem to have a higher impact in foot pad lesions scores, when these activity and distribution patterns are monitored at individual camera level at

the house. The sample size used in this study is small, so this approach is going to be checked in both, more rearing cycles and more farms.

Acknowledgements

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References

Aydin, A., Cangar, O., Eren Ozcan, S., Bahr, C., Berckmans, D., 2010. Application of a fully automatic analysis tool to assess the activity of broiler chickens with different gait scores. Computers and Electronics in Agriculture 73, 194-199.

Berckmans, D., 2008. Precision livestock farming (PLF). Computers and Electronics in Agriculture 62, 1.

De Wet, L. Vranken, E. Chedad, A., Aerts, J.M., Ceunen, J., Berckmans, D., 2003. Computer-assisted image analysis to quantify daily growth rates of broilers chickens. British Poultry Science 44 (4), 449-457.

Dawkins, M. S., Russell, C., Roberts, S.J., 2012. Optical Flow, flock behaviour and chicken welfare. Animal Behaviour 84, 219-223.

Dawkins, M. S., Russell, C., Merelie, K., Roberts, S.J., 2013. In search of the behavioural correlates of optical flow patterns in the automated assessment of broiler chicken welfare. Applied Animal Behaviour Science 145, 44-50.

FAO (Food and Agricultural Organization), 2013. Poultry Development Review. Rome.

Haslam S.M., Knowles T.G., Brown S.N., Wilkins L.J., Kestin S.C., Warriss P.D., C.J. Nicol (2007). Factors affecting the prevalence of foot pad dermatitis, hock burn and breast burn in broiler chicken, British Poultry Science, 48:3, 264-275.

Kashiha, M., Pluk, A., Bahr, C., Berckmans, D., 2013. Development of an early warning system for a broiler house using computer vision. Biosystems Engineering 116, 139-147.

Tullo, E., Fontana, I., Guarino, M., 2013. Precision livestock farming: an overview of image and sound labelling. In: Berckmans and Vandermeulen (eds.) Precision Livestock Farming ’13, pp. 30 – 38.

Weeks, C.A., Danbury, T.D., Davies H.C., Hunt, P., Kestin, S.C., 2000. The behaviour of broiler chickens and its modification by lameness. Applied Animal Behaviour Science 67, 111-125.

Welfare Quality® (2009). Welfare Quality® assessment protocol for poultry (broilers, laying hens). Welfare Quality® Consortium, Lelystad, Netherlands.